December 2007

Collaboration Engineering for Interdisciplinary Teams

John Murphy
University of Nebraska Omaha

Gary Ozanich
UNO

Collaboration Engineering for Interdisciplinary Teams

John D. Murphy
University of Nebraska, Omaha
jmurphy@mail.unomaha.edu

Justin Yurkovich
University of Nebraska, Omaha
jyurkovich@mail.unomaha.edu

ABSTRACT

Many organizations depend on group processes, and collaboration in particular, as a foundation for successful business activities. However, collaboration presents its own challenges that can reduce a team's performance, with teams sometimes suffering from disagreements over the team's purpose and goals, poor communication, or any of a host of other problems. These difficulties are exacerbated when teams are composed of people from diverse academic disciplines. This study examines the background of group processes and collaboration to better understand challenges specific to interdisciplinary groups. It then applies this understanding to engineer a collaborative process for planning interdisciplinary research and development initiatives for an exemplar organization that depends heavily on interdisciplinary teams and generalizes the lessons learned from that effort.

Keywords (Required)

Collaboration engineering, interdisciplinary, groupthink, disciplinary ethnocentrism.

INTRODUCTION

In 2004, the National Institute of Standards issued a report that estimated the cost of inadequate interoperability in the U.S. capital facilities industry to be $15.8 billion per year (Gallaher, O'Conner, Dettbarn & Gilday, 2004). Industry is now fast-tracking development and deployment of technologies to substantially improve how capital projects and facilities are designed, engineered, built, and maintained. The rapid pace of change in the private sector caused by advances in technology mandates that academic programs assess their educational and research plans to ensure they are producing graduates that are valuable in the workforce. Three colleges from the University of Nebraska system – the Colleges of Architectural Engineering, Construction Systems, and Information Sciences and Technology – partnered to meet this challenge.

This research effort was specifically targeted at one aspect of that overall challenge, helping these three colleges identify and plan for interdisciplinary Research and Development (R&D) opportunities. The strategy chosen for the effort was to employ a Collaboration Engineering (CE) approach to the design of a process for the meetings that teams with representatives from each of the three colleges could use to develop their collaborative research initiatives. Developing a design of a process for collaborative identification of potential interdisciplinary research and development initiatives for building industry partners required us to answer the following research question:

> *How can building industry stakeholders representing diverse disciplines effectively and efficiently conduct a collaborative planning process that identifies practical, executable R&D initiatives?*

To answer this question, we'll first examine three bodies of knowledge that form the background of our problem situation: group processes, interdisciplinary collaboration, and collaboration engineering. Next, we'll describe how key challenges to successful interdisciplinary collaboration identified in that background – ineffective brainstorming, groupthink, and disciplinary ethnocentrism -- can be met through the purposeful selection of specific collaborative activities to achieve the session's purpose. After presenting a session design that is tailored to address specific interdisciplinary challenges, we'll propose a set of measures to assess the validity of the design, and then we'll capture our lessons learned from building a theory-driven design. While there have been numerous studies that examined the overall CE approach, and the idea that session designs should be purposeful is well-established (Vreede and Briggs, 2005), less attention has been paid to the interdisciplinary aspects of collaboration. Improved understanding of the unique challenges this type of group can present will further refine the application of CE principles to an important segment of groups needing support in designing collaborative sessions.

BACKGROUND

Whenever two or more people work together, you de facto have a group and all of the dynamics that group processes entail. For this study, the group has been assigned to collaborate on developing a list of potential interdisciplinary R&D opportunities for three colleges. Many organizations rely on similar group processes, and collaboration in particular, as a

foundation for successful business. But, as Kolfschoten, Briggs, and Vreede (2006) point out, collaboration can be a mixed blessing; disagreements over the team's purpose and goals, lack of reliable information to base decisions upon, and poor communication are just a few of the challenges that can reduce a team's performance. These difficulties are exacerbated when the team is composed of people from diverse academic disciplines (Campbell, 2005; Klein, 2005).

Group Processes

A common strategy used by groups to produce solutions to a problem is brainstorming (Osborn, 1957 as cited in Mullen & Johnson, 1991). In its initial conception, brainstorming was thought to be more a more productive way for a group of individuals to produce solutions to a problem. This notion is in keeping with the traditional view that a group can achieve more together than is possible as individuals (Osborn, 1957 as cited in Mullen & Johnson, 1991). However, a meta-analysis of group brainstorming literature performed by Mullen and Johnson (1991) showed that the decline in productivity that groups experience is both pervasive and significant.

Two sources of downfall for group functioning that are especially relevant to brainstorming are social loafing and groupthink (Karau & Williams, 1993; Mullen, Anthony, Salas & Driskell, 1994). Social loafing is best described as the reduction in both motivation and effort that results from individuals working together as compared to the levels achieved when working individually or coactively. Initially studied over a hundred years ago by Ringelman (as cited in Kravitz & Martin, 1986) decreases in group performance were noted when individuals were not directly accountable for their performance in collective tasks. Subsequent research on the phenomenon discovered that individuals who perceived their contributions to a group goal to be anonymous exerted less effort than individuals whose contributions were identifiable to others (Ingham, Levinger, Graves & Peckham, 1974)

As group performance is most vulnerable to social loafing when tasks are collective and individual contributions are largely unidentifiable, the simplistic solution is to hold individual members accountable for their contributions. While this solution may alleviate social loafing by specifically identifying participant contributions, taking away that anonymity can lead to groupthink.

First coined by Irving Janis in 1971, groupthink describes the tendency for a group to avoid negatively-perceived social consequences within the group when evaluating contributions. A group that experiences groupthink will seek to maintain unanimity and consensus regardless of possible errors in direction or effort. Classic examples of this phenomenon are the decisions made surrounding the Bay of Pigs Invasion in 1961, and the NASA Space Shuttle Challenger explosion in 1986. In both cases incorrect actions were not challenged or questioned due to a desire to maintain consensus within a group (Janis, 1982; Moorhead, Ference & Neck, 1991).

The manifestation of groupthink is rooted in inadequate effort to reasonably appraise alternate courses of action (Janis, 1972 as cited in Mullen et al., 1994). Consequently, if groups are to prevent groupthink, alternative suggestions must be appraised objectively and without bias. Furthermore, sufficient time must be spent on the evaluation process so that flaws and drawbacks to solutions are not overlooked. These factors become significant in designing a collaboration session and will be discussed further in that section of the paper.

Brown and Paulus (2002) also made suggestions to enhance group brainstorming while minimizing risks associated with groupthink. Their suggestions included ensuring that groups alternate between individual and group ideation, and that they use electronic brainstorming tools. Alternating between forms of ideation helps promote careful reflection on the different contributions made by group members, alleviating social pressure towards consensus that can occur in direct social interaction (Brown and Paulus, 2002). Electronic brainstorming tools are particularly helpful because the anonymity features available with that technology allows group members to voice potentially unpopular criticisms absent of pressure to maintain group cohesion (Connelly, Jessup & Valacich, 1990). Anonymity helps ensure all opinions are evaluated equally, regardless of the social status of the contributor. (ibid).

Interdisciplinary Groups

For the purposes of this paper, we define interdisciplinary groups as groups with members drawn from different academic disciplines formed to accomplish a specific purpose. Academic environments like a university provide rich opportunities for such groups, though it is important to note that this idea applies to any group composed of people from multiple disciplines.

O'Donnell and Derry (2005) held that if heterogeneous groups are going to benefit from including different disciplines on a team, they must "consciously integrate knowledge from the different disciplines included" (p.54). Campbell (2005) struck a similar theme, noting that a primary barrier to effective communication and interaction across disciplines is what he called ethnocentrism of disciplines. Campbell drew parallels to the phenomenon that occurs when nationalistic or tribalistic

tendencies occur in other contexts and conveyed that ethnocentrism of disciplines leads disciplines to look within themselves for solutions rather than including people from other disciplines. Campbell went on to say that this phenomenon isolates that group from skills, knowledge, and perspectives that may be useful.

To achieve better collective comprehensiveness in solutions, Campbell (2005) advocates that interdisciplinary groups must consciously create "overlapping patterns of unique narrowness" (p.3) as they interact to solve problems. These overlapping patterns serve to focus each discipline's knowledge and experience on various aspects of the problem, yielding a more robust solution (ibid). Carrying this idea a step further, the heterogeneous nature of interdisciplinary groups can also be beneficial in preventing phenomena like groupthink when those different perspectives are integrated.

Brown and Paulus (2002) also investigated the effects of bringing heterogeneous knowledge groups together. They suggested that groups in which the individuals possess diverse knowledge can benefit from a social exchange of ideas to a larger extent than groups with more homogenous knowledge across group members. They went on to link this idea to other improvements in group processes, indicating that enhanced social exchange in group settings provides opportunities to clarify meaning and terminology that may not be clear across disciplines, as well as allowing for increased integration of concepts between disciplines.

This pattern of social interaction also has implications for reducing groupthink. Brown and Paulus (2002) point out that people who brainstorm individually following a group session will produce more ideas, which results in a greater variety of responses that may in turn help reduce groupthink. This increased number and variety of ideas is likely to produce longer, more wide-ranging discussion of options, which brings more perspectives into the evaluation of those ideas (ibid). This effect is heightened when perspectives from multiple disciplines is integrated into the process (Campbell, 2005).

Collaboration Engineering

Briggs, Vreede and Nunamaker (2003) define Collaboration Engineering (CE) as an approach to the design and deployment of reusable collaborative processes that support mission-critical tasks. Vreede and Briggs (2005) built upon this definition in their article "Collaboration Engineering: Designing Repeatable Processes for High-Value Collaborative Tasks" where they describe a Collaboration Engineer as a person who uses expert knowledge of facilitation and collaborative tools to design a process that practitioners can repeatedly use in their specific circumstances.

Briggs, Vreede & Nunamaker (2003) posited that to achieve a goal collaboratively, people must move through a reasoning process that consists of a core set of basic patterns of collaboration. The following table enumerates and defines those patterns of collaboration.

Pattern of Collaboration	**Purpose: To move the group from**
Diverge	having fewer concepts to having more concepts.
Converge	having many concepts to having fewer concepts.
Organize	less understanding to more understanding of conceptual relationships.
Evaluate	less understanding of the value of concepts to more understanding.
Build Consensus	less agreement among stakeholders to more agreement.

Table 2: Patterns of Collaboration

These patterns of collaboration represent the steps a Collaboration Engineer would use to develop a process design, and they are instantiated through the use of ThinkLets (Vreede & Briggs, 2005). A ThinkLet represents one repeatable, predictable collaboration activity that can move a group toward a goal (ibid). ThinkLets can be combined in different ways to build a tailored group process. This tailored process, built by a Collaboration Engineer, then becomes a packaged, repeatable pattern of collaboration that moves people toward their stated goals (ibid).

Vreede and Briggs (2005) further argued that all CE interventions (a purposeful combination of ThinkLets used to move a group toward a specific goal, in CE parlance) are meant to cause particular outcomes. Extending this idea, to be purposeful, an intervention should be built upon theoretical foundations that suggest what these expected outcomes should be. This study emphasized using collaboration components efficacious to the interdisciplinary nature of our subjects.

From this viewpoint, the CE approach provides strong benefits to process design. First, the pre-defined ThinkLets inherent in the CE process have been shown to yield predictable results (Briggs & Vreede, unpublished). Consequently, Collaboration Engineers can be assured that if they combine ThinkLets that are focused on the participants' needs and guided by underlying theory, they will develop a process that they can have confidence in. Second, by following the CE design guidelines, the resultant process has potential to become a 'best practice' for an entire community of interest rather than being limited to a

specific setting. The CE approach may take longer and as a result cost more (Dean, Deokar & Bush, 2006), but it represents a conscious investment oriented around the best long-term process.

SESSION DESIGN

The product of a CE project is a collaboration process design, which will be presented now. As we were informed by the theoretical work described above, there were several key points relative to group processes, and interdisciplinary collaboration in particular, that guided the design effort. Some of the potential problem areas the theory identified are inherent in any group processes, and are simply exacerbated under an interdisciplinary scenario. Others manifest primarily in interdisciplinary group processes. The potential problems identified in the Background section were:

- Less effective brainstorming activities.
- Propensity toward "group think."
- Disciplinary Ethnocentrism.

The success of an interdisciplinary collaboration session depends on the degree to which the session design addresses these potential challenges. In general, our approach to addressing these issues was to ensure that all participants had ample opportunity to get their ideas out into the open for everyone to consider, and then devote adequate time to developing shared understanding of those ideas (Campbell, 2005; Klein, 2005). But each step of the overall meeting process required its own particular instantiation of these general guidelines. The major steps of our process, represented as a Facilitation Process Model using the CE-specific notations proposed by Vreede and Briggs (2005), were

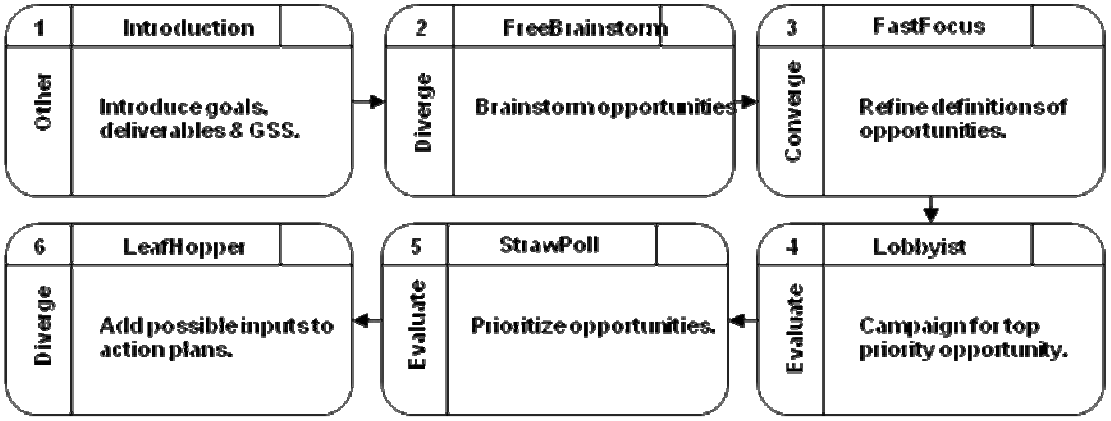

Figure 1: FPM for Identifying Interdisciplinary R&D Opportunities

SESSION EXECUTION

The first step of the process is to brainstorm practical interdisciplinary research and development (R&D) opportunities. Previous studies have identified the use of electronic brainstorming as a viable strategy to increase the effectiveness of ideation sessions (Dennis, Aronson, Heninger, Walker, 1999; Gallupe, Dennis, Cooper, Valacich, Bastianutti & Nunamaker, 1992). From the standpoint of addressing specific interdisciplinary needs, using the FreeBrainstorm ThinkLet with the anonymity feature enabled, and actively encouraging everyone to contribute any ideas they thought were appropriate, help avoid group think (Brown & Paulus, 2002) and foster social exchange (Klein, 2005) that ameliorates potential effects of disciplinary ethnocentrism (Campbell, 2005).

After brainstorming a list of many potential opportunities, the group needed to create clear, concise, non-redundant statements of R&D opportunities using the FastFocus ThinkLet. FastFocus uses a guided dialogue format to promote social exchange as recommended by Brown and Paulus (2002), Campbell (2005), and Klein (2005). This social exchange helps build shared understanding, brings diverse disciplinary knowledge sets to bear, and helps participants understand additional ways they can contribute to projects that they might have ignored without appropriate discussion. As a result, the social exchange inherent in this step improves every facet of interdisciplinary teamwork – producing better overall quality ideas while avoiding groupthink and disciplinary ethnocentrism (Brown & Paulus, 2002; Campbell, 2005; Klein, 2005).

With a clean list of non-redundant, mutually-understood R&D opportunities created, the group needed to prioritize those opportunities. This step actually had two stages. First, the facilitator used the Lobbyist ThinkLet where each participant got

the opportunity to individually advocate for the one project he/she felt was most important. This ThinkLet ensured equal participation (Briggs & Vreede, unpublished), which helps erode disciplinary ethnocentrism. Then, a non-binding, anonymous StrawPoll ThinkLet was used. The anonymity feature in this ThinkLet allowed participants to evaluate ideas without attribution which could expose them to social pressures. This approach helps avoid the group think and disciplinary ethnocentrism issues (Mullen et al, 1994; Campbell, 2005). Together these ThinkLets also helped build consensus and shared understanding amongst the participants (Briggs, Vreede & Nunamaker, 2003; Klein, 2005).

The last major step was to gather inputs for action plans. The LeafHopper ThinkLet created individual discussion sheets for each of the top priority R&D opportunities, and the facilitator instructed the participants to add ideas to any sheets where they thought they had experience or expertise to contribute. The participants were also asked to review all of the other sheets to help contribute their particular disciplinary perspectives to all potential projects. This was another step where each participant had the opportunity to see how they could fit into different projects, helping reinforce that sense of interdependence and teamwork necessary for project success (Campbell, 2005). Furthermore, critiquing each other's inputs leads to a more coherent and comprehensive solution (Klein, 2005), which also helped the group steer clear of groupthink.

The following table ties the ideas of the last several paragraphs together, linking the process steps to the pattern of collaboration each step represents, the implementing ThinkLets, and the problems addressed by the choice of those ThinkLets:

Process Step	Collaboration Pattern	ThinkLet	Interdisciplinary problem addressed/benefit
Identify opportunities	Diverge	FreeBrainstorm	Improved brain storming; Group Think; Disciplinary Ethnocentrism
Clean-up List	Converge	FastFocus	Improved brain storming; Disciplinary Ethnocentrism
Prioritize opportunities	Evaluate	Lobbyist	Group Think; Disciplinary Ethnocentrism
	Evaluate	StrawPoll	Group Think; Disciplinary Ethnocentrism
Build action plans	Diverge	LeafHopper	Group Think; Team interdependence

Table 3: Process-Pattern-ThinkLet-Problem Linkages

This specific combination of thinkLets is one example built from the roughly 50 thinkLets available for collaborative activities. We are not advocating that this is the only combination that could work, or that this is the best combination for every similar collaborative task; other combinations may work as well. The point of presenting this combination is to illustrate that there are thinkLets available that can help address challenges specific to interdisciplinary groups, and Collaboration Engineers can design processes that account for interdisciplinary concerns using existing thinkLets.

One last observation on this overall process comes from Marrow and French in their article "Changing a Stereotype in Industry" (as cited in Churchman & Schainblatt, 1965) where they noted by moving through a guided experience with people from other backgrounds participants can assimilate attitudes which they might not have accepted directly from the other participants. Extending their concept, our expectation is that the moving the interdisciplinary group through the process of this session design will help overcome stereotypes, further enhancing the benefit of each specific steps in the design.

EVALUATING SESSION RESULTS

Measuring session results is a critical aspect of deciding if a collaborative process design is effective and useful. Pinsonneault and Kraemer (1990) noted that collaboration processes in general have two types of outcomes: task-related outcomes and social outcomes. The rationale for these categories is that people will only continue to use a collaborative session design if (1) they believe they were productive at it, and (2) they are satisfied with the results. Accordingly, Pinsonneault and Kraemer suggested that both aspects be evaluated to determine the effectiveness of collaboration sessions. For this interdisciplinary collaboration session, their recommendation translates into measuring (1) the productivity of the ideation activity and (2) participant perceptions of the constructs relevant to this study – satisfaction, groupthink, and disciplinary ethnocentrism. The following table summarizes this study's measurement strategy:

Construct	Measurement
Productivity	Count the number of non-redundant inputs from the ideation session. (Gallupe, 1992)
Satisfaction	Measured via survey administered at the end of each session. Specific questions for this phenomenon of interest listed in Table x: Survey Results. (Gallupe et al, 1992)
Groupthink	Measured via survey administered at the end of each session. Specific questions for this phenomenon of interest listed in Table x: Survey Results. (Gallupe et al, 1992)

Disciplinary Ethnocentrism	Measured via survey administered at the end of each session. Specific questions for this phenomenon of interest listed in Table x: Survey Results. (Gallupe et al, 1992)

Table 4: Construct Measurement

While productivity is always something the organization will be interested in, it is also important that the participants feel that the session process itself did not constrain their opportunity to contribute, and that the group interactions do not result in reduced individual performance. Because these measures aimed at how the participants feel about the process, these perceptions could be evaluated with a questionnaire at the end of the session. The following table proposes specific question for each of these constructs.

Satisfaction
Were you satisfied with the process used today?
Would you advocate this process for others to use to generate ideas?
Groupthink
My contributions to the group were anonymous to the other group members
Anonymity allowed me to effectively critique contributions made by other group members.
Contributions were evaluated on the merit of the contribution, rather than by who made the contribution.
Outcomes selected by the group were chosen based on a comparison of the qualities to other possible outcomes.
Participants were willing to question proposals put forth by other participants.
Participants offered alternative solutions to problems.
Disciplinary Ethnocentrism
Contributions made by group members from other disciplines had an effect on the quality of meeting outcomes.
Of the disciplines represented within the group, my discipline is best for addressing the group's goal(s).
There are many issues in my field that can be addressed using other perspectives held by different disciplines.
Contributions made by group members from other disciplines were largely out of self interest.
Scoring: 5-point Likert scale; "1" indicates Strongly Disagree and "5" indicates Strongly Agree

Table 5: Survey Questions

CONCLUSIONS

Engineering any collaborative session involves making a series of choices that are ultimately guided by the participants' purpose for meeting. Different patterns of collaboration are linked together to lead the group through a series of activities necessary to achieve this purpose. These patterns of collaboration are instantiated through the use of ThinkLets, and ThinkLets are linked together to develop a tailored, repeatable, predictable sequence of activities that logically moves the group toward their goal. Making the choices of which ThinkLet to use at each step and how to use these ThinkLets lies at the heart of successful CE.

In the case of CE for interdisciplinary teams, we've seen that there is a substantial body of theory to help guide those choices. For example, research suggests that exploiting the availability of anonymity in electronic brainstorming can lessen the impact groupthink when a team is exploring possible solutions, and knowing this would encourage the selection of a FreeBrainstorm ThinkLet. Other research identified disciplinary ethnocentrism as a significant concern when working with interdisciplinary teams, so a collaboration engineer would be advised to choose ThinkLets like the FastFocus and Lobbyist. These ThinkLets encourage higher levels of social exchange that better ensure that different perspectives are included in the discussion, thereby helping ameliorate stereotyping endemic to ethnocentrism. Moreover, these ThinkLets, along with the StrawPoll ThinkLet, also help promote shared understanding amongst the different team members (and therefore disciplines), which research suggests can also lessen the effects of both groupthink and ethnocentrism.

Knowing how the ThinkLets work together, and being abler to sequence them logically and effectively is vital to the success of any collaboration engineering effort. Understanding the special needs of interdisciplinary teams allows a collaboration engineer to be even more effective.

REFERENCES

1. Briggs, R. O., and Vreede, G. J. De. (unpublished). ThinkLets: Building Blocks for Concerted Collaboration, version 1.0.
2. Briggs, R. O., Vreede, G. J. de, and Nunamaker, J. F. Jr. "Collaboration Engineering with ThinkLets to Pursue Sustained Success with Group Support Systems." Journal of Management Information Systems (19:4), 2003, pp. 31-63.

3. Brown, V. R., and Paulus, P. B. "Making Group Brainstorming More Effective: Recommendations from an Associative Memory Perspective." Current Directions in Psychological Science (11:6), December 2002, pp. 208-212.
4. Campbell, D. T. "Ethnocentrism of Disciplines and the Fish-scale Model of Omniscience." In Derry , S. J., Schunn, C. D., & Gernsbacher, M. A. (Eds.), Interdisciplinary Collaboration: An Emerging Cognitive Science, 2005, pp. 3-23. Mahwah: Lawrence-Elrbaum.
5. Churchman, C. W., and Schainblatt, A. H. "The Researcher and the Manager: A Dialectic of Implementation." Management Science (11:4)**,** February 1965, pp. B69-B87.
6. Connolly, T., Jessup, L. M., and Valacich, J. S. "Effects of Anonymity and Evaluative Tone on Idea Generation in Computer-Mediated Groups." Management Science (36:6), June 1990, pp. 689-703.
7. Dean, D.L., Deokar, A., and Bush, R. T. "Making the Collaboration Engineering Investment Decision." Proceedings of the Thirty-Ninth Annual Hawaii International Conference on System Sciences, January 2006, 10 pages.
8. Dennis, A. R., Aronsen, J. E., Heninger, W. G., and Walker, E. D. "Structuring Time and Task in Electronic Brainstorming." Management Information Systems Quarterly, (*23*:1), March 1999, pp. 95-108.
9. Gallaher, M. P., O'Conner, A. C., Dettbarn, J. L. & Gilday, L. T. "Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry." National Institute of Standards Report NIST GCR 04-867. August 2004.
10. Gallupe, R. B., Dennis, A. R., Cooper, W. H., Valacich, J. S., Bastianutti, L. M., and Nunamaker, J. F. "Electronic Brainstorming and Group Size." Academy of Management Journal (35:2), June 1992, pp. 350-369.
11. Ingham, A. G., Levinger, G., Graves, J., & Peckham, V. "The Ringelmann Effect: Studies of Group Size and Group Performance." Journal of Experimental Social Psychology, 10*,* 1974, pp. 371-384.
12. Janis, I. L. "Groupthink." Psychology Today, November 1971*,* pp 43-46, 74-76.
13. Janis, I. L. Groupthink: Psychological studies of policy decisions and fiascoes (2nd ed.). Boston: Houghton Mifflin. 1982.
14. Karau, S. J., & Williams, K. D. "Social loafing: A Meta-analytic review and theoretical integration." Interpersonal Relations and Group Processes (65), 1993, pp. 681-706.
15. Klein, J. T. "Interdisciplinary Teamwork: The Dynamics of Collaboration and Integration." In Derry , S. J., Schunn, C. D., & Gernsbacher, M. A. (Eds.), Interdisciplinary Collaboration: An Emerging Cognitive Science, 2005, pp. 23-50. Mahwah: Lawrence-Elrbaum.
16. Kolfschoten, G. L., Briggs, R. O., and Vreede, G. J. de. "Definitions in Collaboration Engineering." Proceedings of the Thirty-Ninth Annual Hawaii International Conference on System Sciences. January 2006, 8 pages.
17. Kravitz, D. A., and Martin, B. "Ringelmann Rediscovered: the Original Article. Journal of Personality and Social Psychology (50:5), May 1986, pp. 936-941.
18. Moorhead, G., Ference, R., and Neck, C. P. "Group Decision Fiascoes Continue: Space Shuttle Challenger and a revised framework." Human Relations (44:6), 1991, pp. 539-550.
19. Mullen, B., Johnson, C., and Salas, E. "Productivity Loss in Brainstorming Groups: A Meta-analytic Integration." Basic and Applied Social Psychology (12:1), March 1991, pp. 3-23.
20. Mullen, B., Anthony, T., Salas, E., and Driskell, J. E. "Group Cohesiveness and Quality of Decision Making: an Integration of Tests of the Groupthink Hypothesis." Small Group Research (25), 1994, pp.189-204.
21. O'Donnell, A. M., and Derry, S. G. "Cognitive Processes in Interdisciplinary Groups: Problems and Possibilities. In Derry, S. J., Schunn, C. D., & Gernsbacher, M. A. (Eds.), Interdisciplinary Collaboration: An Emerging Cognitive Science*,* 2005, pp. 51-82. Mahwah: Lawrence-Elrbaum.
22. Osborn, Alex F. Applied Imagination, 1939. New York: Charles Scribner's & Sons.
23. Pinsonneault, A. & Kraemer, K. L. "The Effects of Electronic Meetings on Group Processes and Outcomes: an Assessment of the Empirical Research." European Journal of Operational Research (46), 1990, pp. 143-161.
24. Susman, G. I. and Evered, R. D. "An Assessment of the Scientific Merits of Action Research." Administrative Science Quarterly (23:4), December 1978, pp. 582-603.
25. Vreede, G. J. de and Briggs, R. O. "Collaboration Engineering: Designing Repeatable Processes for High-Value Collaborative Tasks." Proceedings of the Thirty-Eighth Annual Hawaii International Conference on System Sciences. January 2005, 10 pages.